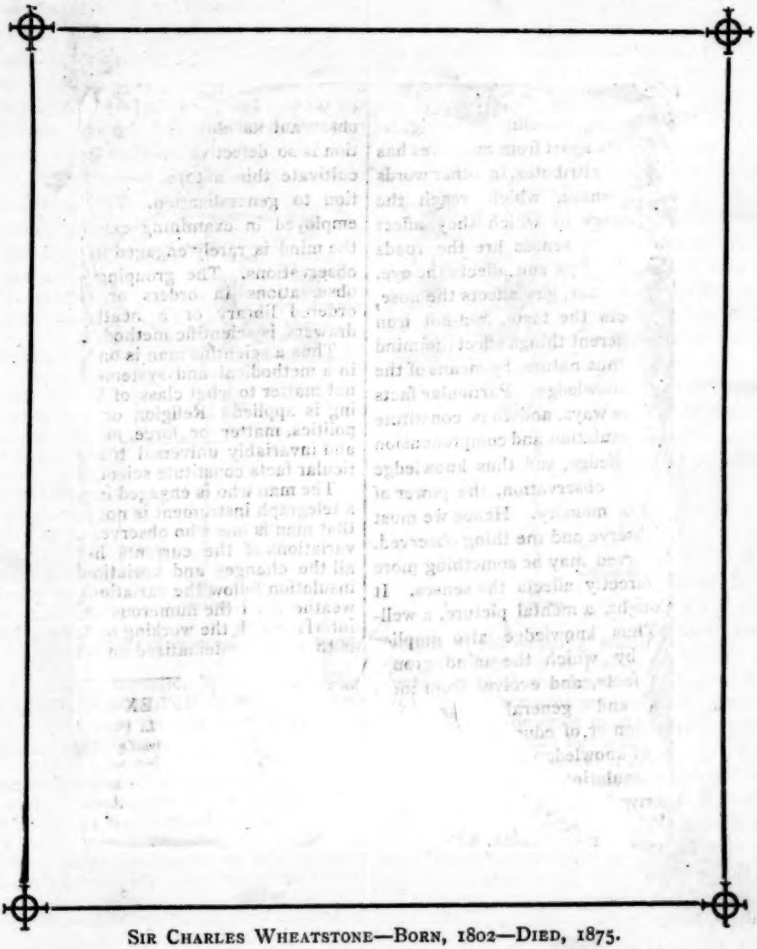
THE

TELEGRAPHIC JOURNAL.

VOL. IV. JANUARY 1, 1876. No. 70.

THE COMPLIMENTS OF THE SEASON.

WE wish our readers a happy and prosperous New Year. We publish with the commencement of this new volume a likeness of Sir Charles Wheatstone, whose classical paper on "The Constants



SIR CHARLES WHEATSTONE—BORN, 1802—DIED, 1875.

(*From a Photograph by* MR. J. E. MAYALL, *being the last taken of* SIR CHARLES).

of a Voltaic Circuit" we are also reprinting. We propose also to publish portraits of our leadin Electricians from time to time, and we will do all we can in the future to deserve the continuance of that support which, we are happy to say, is largely on the increase.

168579

SCIENCE.

THE words science and scientific men are amongst the most ill-used in the English language. We hear of the science of telegraphy, the science of photography, the science of steam, &c., and read of telegraph instruments, cameras, and steam-engines. A scientific man is supposed to be one who brushes his uncut hair back over his ears, wears spectacles on nose, and doesn't believe in the Bible. Science is considered analagous to scepticism, and a scientfic man is regarded as a lost bore.

Now what is science? It is *scientia* or knowledge. But what is knowledge? It is the acquaintance we make with things around us by means of our senses. All that we know is gained either by seeing, hearing, smelling, tasting, or touching. All that exists apart from ourselves has properties, qualities, and attributes, in other words peculiarities and differences, which reach the mind by the different ways in which they affect the various senses. The senses are the roads which lead to the mind. The sun affects the eye, a thunderclap affects the ear, gas affects the nose, a black draught affects the taste, red-hot iron affects the touch. Different things affect the mind in different ways, and thus nature, by means of the senses, imparts to us knowledge. Particular facts appear to us in various ways, and thus constitute *phenomena*. The accumulation and comprehension of phenomena is knowledge, and thus knowledge implies the faculty of observation, the power of comparison, the gift of memory. Hence we must have the mind to observe and the thing observed. But the thing observed may be something more than that which directly affects the senses. It may be a hasty thought, a mental picture, a well-conceived law. Thus knowledge also implies reason; the power by which the mind groups together particular facts, and evolves from them propositions, laws, and general ideas. The power of generalization or of educing principles is therefore a species of knowledge above that power of gathering or accumulating the particular facts from which it is derived, and this universal knowledge is science. The employment of the senses accumulates facts, the memory stores up phenomena, the comparison of phenomena begets differences and similarities, and the mind produces uniformities, laws, and generalizations. Thus we have the power of obtaining knowledge and the results obtained—the one is scientific method the other is scientific lore or knowledge. So that science and universal knowledge are synonymous terms. But science is knowledge methodically digested and systematically arranged, so as to concentrate the observations of the many within the comprehension of the few. It is the accumulation of universal truths from particular facts. And it is not confined to one series of facts or to one kind of phenomena. It has numerous branches. Thus the knowledge of the heavens constitutes the science of astronomy; the knowledge of the constitution of matter constitutes chemistry; of the affections matter, heat, light, and electricity constitute physics, of the motion of matter dynamics; the knowledge of the construction of the earth is geology, and of the properties of vegetable life botany; the knowledge of the mind is physcology, and that of thought logic. The accumulation of knowledge, or the power of generalization, is instinctive in the human mind; what is wanted is the power to classify and arrange. There are none so observant as children; but our system of education is so defective that no effort is ever made to cultivate this natural power and reduce observation to generalization. The senses are always employed in examining external phenomena, but the mind is rarely engaged in systematizing these observations. The grouping or arranging these observations in orders or classes, like a well ordered library or a neatly arranged chest of drawers, is scientific method.

Thus a scientific man is one who examines facts in a methodical and systematic way, and it does not matter to what class of knowledge his reasoning is applied. Religion or language, history or politics, matter or force, may be so investigated, and invariably universal truths derived from particular facts constitute science.

The man who is engaged in simply manipulating a telegraph instrument is not a scientific man, but that man is one who observes all the changes and variations of the currents he uses, showing how all the changes and variations of resistance and insulation follow the variation and changes of the weather, and the numerous cosmical causes that interfere with the working of telegraphs. Science is therefore systematized knowledge.

ON QUADRUPLEX TELEGRAPHY.*

By F. L. POPE.

(From the *Journal of the Telegraph.*)

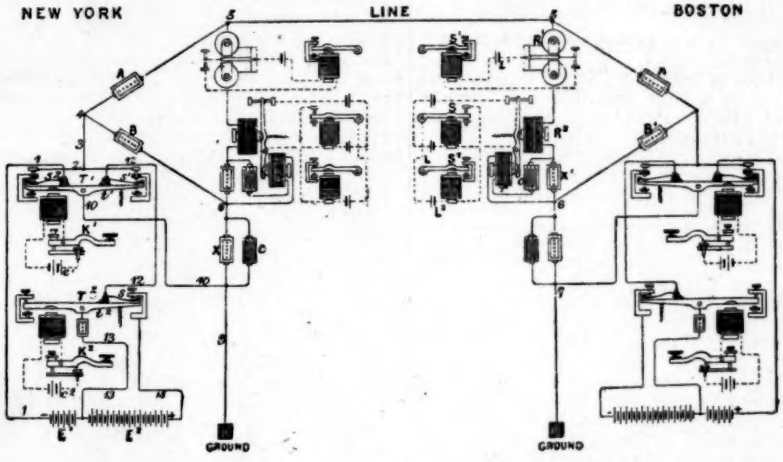
THE simultaneous transmission of two telegraphic communications in opposite directions upon the same wire, now known by the name of duplex telegraphy dates back to the year 1853. The first to conceive of its possibility, as well as the first to carry the conception into practical effect, was Dr. Wilhelm Gintl, Director of State Telegraphs in Vienna, Austria. He described his method in a paper read by him before the Vienna Academy of Sciences on the 9th of June, 1853, and in July of the same year, it was put in practical operation between Prague and Vienna.

In March of the following year, Carl Frischen, a telegraphic engineer of Hanover, Germany, im-

* We have much pleasure in reprinting this very able and clear paper.—Ed. *T. J.*

proved upon Gintl's plan, by making use of a branch current from the main battery for compensating the effect of the outgoing current upon the home relay, instead of the local current employed by Gintl. This is unquestionably the most important improvement which has been made in duplex telegraphy from the time of its original invention by Gintl, down to the time of the addition of the condenser by Stearns, in 1872. Frischen used a differential relay having helices composed of two equal and opposing wires, and an artificial or rheostat line equal in resistance to the main line, substantially as they are used at this day. His first practical experiment was made between Hanover and Gottingen on the 26th of May, 1855.

The labors of Frischen, and of Siemens and Halske of Berlin, who during the same year, independently but subsequently worked out a method almost precisely similar to Frischen's, brought the system of simultaneous transmission in opposite directions to a state of perfection which answered a very good purpose upon the comparatively short lines, and at the slow rate of transmission in vogue at that day.



The success of these ingenious inventions gave an entirely new direction to the minds of the host of enterprising electricians on the continent of Europe, and during the following year, 1855, the problem of simultaneous transmission in the same direction, which naturally suggested itself as the next step in the progress of invention, was solved with more or less success by the independent labours of Dr. J. B. Stark of Vienna, Dr. Werner Siemens, Dr. August Kramer and A. Bernstein, of Berlin, and Dr. J. Bosscha Jr., of Leyden; each of these inventors having published a full account of his method in the latter part of 1855 and the early part of 1856. At least two of them, Stark and Bosscha, clearly saw that the successful solution of the difficult problem of simultaneous transmission in the same direction included as a necessary consequence the solution of the problem of quadruple transmission also; for a knowledge of the invention of Gintl as perfected by Frischen, was all that was needed to show that it was equally applicable either to a single or a double telegraph in one direction. In the first published description of his method, dated at Vienna, October 31, 1855, Stark concludes as follows:

"With the method of double transmission in the same direction, we may also combine that of counter-transmission (*gegensprechen*), and hence arises the possibility of simultaneously exchanging four messages upon one wire between two stations, which will however hardly find any application in practice." * This is unquestionably the earliest published suggestion of what is now known as the quadruplex system.

Dr. Bosscha, in a description of his system read before the Royal Academy of Sciences of Holland, on the 27th of October, 1855, and published in Transactions, vol. iv. p. 101, not only makes the same suggestion, but sets forth in detail a method of accomplishing the result. Having described his method of double transmission in the same direction he says: "Now, if we wind each of the receiving relays with two wires, and divide the current at the sending station according to the plan of Siemens and Halske (Frischen) through the two coils of the home relay in opposite directions, then it becomes practicable for both stations to transmit at the same moment without their own relays being affected by their own transmitted currents, and in this manner it is possible to send four signals simultaneously through one wire. This solves the problem in its largest generality."

Thus Stark and Bosscha, as early as 1855, both recognised the indisputable fact, that the production of a successful method of quadruplex transmission depended solely upon the successful solution of the problem of double transmission in the same direction. If this could be accomplished, it becomes a mere matter of mechanical detail to combine with it Frischen's or any other system of counter-transmission.

It has been stated that methods of double transmission in the same direction were worked out independently, but almost coincidently, by a

* Brix's Journal, II, 224.

number of inventors during the year 1855. The ingenious and active German electricians, recognizing that the accomplishment of this result was the key to simultaneous quadruplex transmission, had diligently laboured at the problem. Let us now consider the results of their labours.

In any system of simultaneous double transmission in the same direction, two keys are required at the sending station, and at least four different electrical conditions of the line must be provided for, one for each of the four following cases:

1. When the first key is closed and the second key open.
2. When the second key is closed and the first key open.
3. When both keys are closed.
4. When both keys are open.

The methods of Stark, Siemens, and Bernstein (No. 1), though varying in detail, were arranged upon one general principle, the four electrical conditions of the line being as follows:

1. A positive current having a strength of 1.
2. A positive current having a strength of 2.
3. A positive current having a strength of 3.
4. No current.

The methods of Bernstein (No. 2), Bosscha, and Kramer, and at a later date those of Schreder (1860), and Maron (1862), were arranged upon another and better principle, as follows:

1. A positive current having a strength of 1.
2. A negative current having a strength of 1.
3. A positive (or negative) current having a strength of 2.
4. No current.

There are two serious difficulties, leaving minor ones out of consideration, which are inherent in every system of simultaneous double transmission in the same direction. In the first place, when either key is passing from its front to its rear contact, it causes a momentary interruption of the signal which is at the same time being transmitted by the other key. Neither Stark nor Siemens suggested any means of overcoming this difficulty. Bosscha and Kramer made use of a device originally invented by Gintl, * viz., that of keeping the battery constantly in the main circuit, but shunted by the key, so that when the latter was depressed the short circuit was broken and the current flowed to line, but when raised the battery was again short-circuited. This plan effectually disposed of the difficulty in question, but was injurious in its effect upon the batteries. Bernstein, however, hit upon the method now in use, that of providing each of his keys with a spring, so arranged as to close the front contact at or before the time of interrupting the rear contact. This difficulty was, therefore, effectually removed as early as 1855. The second difficulty is a still more serious one, and arises in the following manner: In the simultaneous operation of the apparatus there must, of necessity, frequently be a change from a positive to a negative condition, or *vice versa*, of the line, and of the relays or receiving instruments, consequent upon the movement of a single key; yet it is evident that the reversal of the magnetic polarity of a receiving instrument by the action of one key must interfere with a signal which is being given upon it at the same time by the action of the other key. This difficulty is met with, in some form, in every arrangement of the receiving instruments. Stark employed three neutral relays adjusted to varying degrees of sensitiveness in one arrangement, and two polarized and one neutral relay in another, as also did Bosscha and Kramer. Bernstein used a single relay with three armatures, of varying adjustment. Neither Stark nor Siemens suggested any method of remedying this serious defect, and judging from his published paper on the subject, the latter evidently considered it an insurmountable one. Bosscha, Bernstein, and Kramer, by making use of different modifications of the same principle, that of operating the recording instrument or sounder by the opening of a shunt circuit, as the first and last had already done with the main batteries, and by working from the rear instead of the front contact of the receiving relay, theoretically succeeded in surmounting this obstacle. Practically, however, the method of operating a register or sounder by closing and breaking a shunt, is a very unsatisfactory one. It not only exhausts the local battery with great rapidity, but the demagnetization of the iron cores takes place with far less rapidity when the battery is cut off by a shunt even of very small resistance, than when it is completely interrupted by breaking the circuit in the usual way, and this renders it impossible to receive and record the telegraphic signals with the rapidity that is necessary in modern telegraphy.

When these methods came to be tried on lines of a length exceeding 100 or 150 miles, the interference of the static discharges was superadded to the already existing difficulties, and for these reasons the results were on the whole so unsatisfactory that the subject remained in abeyance for many years. The subsequent labors of Schreder, Wartmann, Maron, Schaak, and Zetsche, between 1855 and 1865, though exhibiting great ingenuity and research, added little or nothing of practical value to what had already been done by the earlier inventors in the same field.

The revival of the duplex system in America, and its extensive introduction into practical use, both in this country and in Europe, resulting from the improvements of Joseph B. Stearns,—notably his method of compensating the effects of the static discharge from the line by the application of the condenser, which was made known in the winter of 1871-2—once more turned the attention of electricians to the problem of simultaneous transmission in the same direction.

In a paper published in the *Philosophical Magazine* of June, 1873, Oliver Heaviside, of Newcastle-on-Tyne, England, pointed out, as Stark and Bosscha had done before him, that the invention of a system of simultaneous transmission in the same direction furnished at the same time the solution of the problem of quadruple transmission. He says: "It is theoretically possible to send any number of messages whatever simultaneously in one and the same direction upon a single wire. Now by combination with a null duplex system it becomes obviously possible to send any number of messages in the other direction while the opposite correspondences are going on, and without interference. Thus the working capacities of telegraphic circuits may be increased indefinitely by suitable arrangements. * * * From experiments I

* Brix's Journal, II. 135.

have made I find it is not at all a difficult matter to carry on four correspondences at the same time, namely, two in each direction, and if we may suppose the growth of telegraphy will be as rapid in the future as it has been in the past, it seems not improbable that multi-telegraphy will become an established fact."

During the summer of 1874, T. A. Edison, of Newark, N. J., while engaged in conjunction with George B. Prescot, electrician of the Western Union Telegraph Company at New York, in experimenting upon Stearns's duplex apparatus with a view of introducing certain modifications and improvements therein, devised a system of simultaneous transmission in the same direction which differed materially in principle from any of its predecessors, and which was destined to furnish the basis of the first practical solution of the curious and interesting problem of quadruplex telegraphy.

The distinguishing principle of this method consists in combining together two distinct and unlike methods of single transmission, in such a manner that they may be carried on independently upon the same wire, and at the same time without interfering with each other. One of these methods of single transmission is used principally in England, where it is known as the double-current system, and the other is the single-current or open circuit system, used on the continent of Europe. In the double-current system the battery remains constantly in connection with the line at the sending station, its polarity being completely reversed at the beginning and at the end of every signal without breaking the circuit. The receiving relay is provided with a polarized or permanently magnetic armature, but has no adjusting spring, and its action depends solely upon the reversals of polarity upon the line, without reference to the strength of the current. In the single-current system, on the other hand, the transmission is effected by closing and breaking, or increasing and decreasing the current, while the relay has a neutral or soft iron armature, provided with a retracting spring. In this system the action depends solely upon the strength of the current, its polarity being altogether a matter of indifference.

It will therefore be apparent that by making use of these two distinct qualities of the current, viz., polarity and strength, two sets of instruments may be operated, at the same time, on the same wire. This method possesses, moreover, the important practical advantage that the action of each of the two receiving relays is perfectly independent. Each receiving operator controls his own relay and can adjust it to suit himself without interfering with the other, a peculiarity that none of the former methods possessed. As soon as this method was practically worked out, it became at once obvious that any of the different methods of simultaneous transmission in opposite directions already in use might be applied to it, as Stark, Bosscha, and others had long ago pointed out, the result of which would be a practical system of quadruplex transmission. This was shortly afterwards done upon the lines of the Western Union Telegraph Company between New York and Boston, a distance of 240 miles, and both the bridge and the differential system of duplex working were tried in combination with it, with excellent results. When, however, the apparatus was experimentally tested on a circuit of about 450 miles, the effects of static induction became very strongly marked, and it was found that these could be more conveniently compensated in the bridge than in the differential system. The former was, therefore, decided upon as being better suited to the usually existing conditions than the latter.

The diagram shows the quadruplex apparatus as arranged upon the bridge plan.

t^1 is a double current transmitter or pole-changer, operated by an electro-magnet, local battery e^1, and finger key k^1, in a manner well understood. The office of the transmitter t^1 is simply to interchange the poles of the main battery E_1 with respect to the line and ground wires, whenever the key K_1 is depressed; or, in other words, to reverse the polarity of the current upon the line by reversing the poles of battery E_1. By the use of properly arranged spring contacts s_1 s_2, this is done without at any time interrupting the circuit. Thus the movements of the transmitter t^1 cannot alter the strength of the current sent out to the line, but only its polarity or direction. The second transmitter t^2 is operated by a local circuit and key K^2 in the same manner. It is connected with the battery wire 12, of the transmitter t^1 in such a way that when the key K^2 is depressed, the battery E^1 is enlarged by the addition of a second battery E^2 of two to three times the number of cells, by means of which it is enabled to send a current to the line of three or four times the original strength, but the polarity of the current with respect to the line of course still remains as before, under control of the first transmitter t^1.

At the other end of the line are the two receiving instruments R^1 and R^2. R^1 is a polarized relay with the permanently magnetic armature, which is deflected in one direction by positive, and in the other by negative currents, without reference to their strength. This relay consequently responds solely to the movements of key K^1, and operates the sounder S_1, by a local circuit from battery L_1 in the usual manner. Relay R^2 is placed in the same main circuit, and is provided with neutral or soft iron armature, and responds with equal readiness to currents of either polarity, provided they are strong enough to induce sufficient magnetism in its cores to overcome the tension of the opposing armature-spring. The latter, however, is so adjusted that its retractile force exceeds the magnetic attraction induced by the current of the battery E_1, but is easily overpowered by that of the current from E_1 and E_2 combined, which is three or four times as great. Therefore, the relay R^2 responds only to the movements of key K^2 and transmitter t^2.

The same difficulty which had baffled former inventors arises, however, in this connection. When the polarity of the current upon the line is reversed during the time in which the armature of R^2 is attracted to its poles, the armature will fall off for an instant, owing to the cessation of all attractive force at the instant when the change of polarity is actually taking place, and this would confuse the signals by false breaks if the sounder were connected in the ordinary way. By the arrangement shown in the figure, the armature of the relay R^2 makes contact on its back stop,* and a

* The figure shows a second local battery in this circuit, but it is an evident error.—Ed. *T. J.*

second local battery L_2 operates the receiving sounder S_2. Thus it will be understood that when relay R^2 attracts its armature, the local circuit of sounder S_2 will be closed by the back contact of local relay S; but if the armature of R^2 falls off it must reach its back contact, and remain there long enough to complete the circuit through the local relay S, and operate it, before the sounder S_2 will be affected. But the interval of no magnetism in the relay R^2, at the change of polarity, is too brief to permit its armature to remain on its back contact long enough to affect the local relay S, and through the agency of this ingenious device the signals from K_2 are properly responded to by the movements of sounder S_2.

By placing the two receiving instruments R and R_1 in the bridge wire of a "Wheatstone balance," according to Stearns's patent of Nov. 12, 1872, and duplicating the entire apparatus at each end of the line, the currents transmitted at either station do not affect the receiving instruments at that station. Thus in figure 1 the keys K_1 and K_2 are supposed to be at New York, and their movements are responded to only by the receiving relays R_1 and R_2 at Boston. The duplicate parts which are not lettered operate precisely in the same manner, but in the opposite direction with respect to the line.

In applying this system of quadruplex transmission upon lines of considerable length, it was found that the interval of no magnetism in the receiving relay R^2 (which, as above stated, takes place at every reversal of the polarity of the line current), was greatly lengthened by the action of the static discharge from the line, so that the contrivance of the local relay S was not sufficient to overcome the difficulties arising therefrom. A rheostat or resistance, X_1, was therefore placed in the bridge-wire with the receiving instruments R^1 and R^2, and shunted with a condenser *c*, of considerable capacity. Between the lower plate of the condenser and the junction of the bridge and earth-wire an additional electro-magnet, *r*, was placed, acting upon the armature lever of the relay R_2, and in the same direction. The effect of this arrangement is, that when the current of one polarity ceases, the condenser *c* immediately discharges through the magnet *r*, which acts upon the armature lever of relay R_2, and retains it in position for a brief time before the current of the opposite polarity arrives, and thus serves to bridge over the interval of no magnetism between the currents of opposite polarity.

It will be seen that the combination of transmitted currents in this method differs materially from any of those used in previous inventions. They are as follows:

1. When the first key is closed and the second open . . . . . —1
2. When the second key is closed and first open . . . . . +3 or +4
3. When both keys are closed . . —3 or —4
4. When both keys are open . . +1

Here we discover another very important practical advantage in the system under consideration, which is due to the fact that the difference or working margin between the strengths of current required to produce signals upon the polarized relay and upon the neutral relay respectively, may be increased to any extent which circumstances render desirable. Within certain limits, the greater this difference the better the practical results, for the reason that the range of adjustment of the neutral relay increases directly in proportion to the margin. The ratio of the respective currents has been gradually increased from 1 to 2 to as high as 1 to 4, with a corresponding improvement in the practical operation of the apparatus.

From what has been said, therefore, it will be seen that before it became possible to produce a quadruplex apparatus capable of being worked at a commercial rate of speed upon long lines, it was essential that its component parts should have arrived at a certain stage of development. When in the early part of 1872, simultaneous transmission in opposite directions was for the first time rendered practicable upon long lines by the combination therewith of the condenser, the first step was accomplished. It now only remained to invent an equally successful method of simultaneous transmission in the same direction, which, as we have seen, was done in 1874. The application of one or more of the existing duplex combinations to the new invention to form a quadruplex apparatus followed as a matter of course.

Thus it is clear that the merit of the invention of 1874 consists in its having furnished us with a new, and what is more important, a practical method of simultaneous transmission in the same direction, applicable to long lines, and not in the mere application thereto of one or more of the known duplex systems, to form a quadruplex, which in itself would no more constitute an invention in the sense contemplated by the patent law than would the application of the duplex principle to the printing or dial instrument used instead of the Morse, with which it was first used.

As its use becomes more and more extended, the quadruplex is constantly undergoing modification and improvement in its minor details, with a view to render its manipulation more simple and easy, and to enable it to be worked direct between the most widely separated points with the utmost speed and certainty. Some of these modifications are very ingenious and interesting, and will probably form the subject of a future article.

ON A SYSTEM OF TELEGRAPHY.

A Course of Lectures, Delivered at the School of Military Engineering, Chatham. By W. H. PREECE, Member Inst. C.E., &c.

Lecture III.—Commercial Telegraphy—Part II.

(Continued from vol. iii, page 244.)

The speedy restoration of communication upon busy circuits is a matter of such importance that it is a question for great consideration whether it is not advisable to erect, on important trunk lines, a spare wire for the sole purpose of restoring communication when faults occur upon any of the working circuits. Certainly all important centres should and are connected by a sufficient number of wires to leave a margin for pressure due to possible breaks down which cannot always be prevented even on the best organized systems.

But daily tests also effect a second purpose, and that is, they supply the superintendent with a constant record of the condition of the circuits, so as

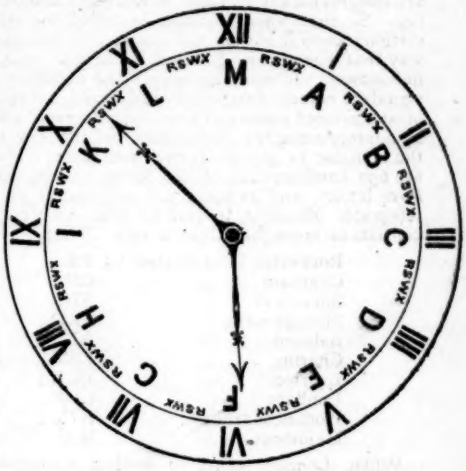
to enable him to anticipate faults and prevent breaks-down. As the seizure of the first indication of weakness will often prevent lameness in a valuable horse, so the seizure of the first warning of a flaw in a circuit will prevent an ugly break-down.

Periodical tests of an exacting and careful character are also applied to all the chief circuits as well as to those which form the morning tangent tests give indications of weakness or failure. These are conducted with the Wheatstone's bridge and resistance coils, and are of a very searching character. They not only afford information as to the electrical condition of the circuits, but they supply data which enable the superintendent to calculate with great nicety the nature and locality of faults when they do occur, and thus to hasten their removal. Careful records of both the daily and periodical tests are kept in the superintendent's office, and the condition of every wire is thus always known to him.

The superintendents act immediately under the orders of the engineer of the division, whose duties are chiefly administrative. He has to provide for the erection and maintenance of circuits and apparatus as they are required; he has to negotiate and maintain complicated arrangements with railway companies, firms, and private individuals; he has to control and watch the working of the circuits in his division to prevent the congestion of work, the growth of delay and to regulate the circulation of messages; he has to prepare for the increasing wants of the system, and to look well ahead; he has especially to maintain discipline in his own department, and to see that the rules and regulations of the service are faithfully discharged.

The Commercial Branch.—The unit of this branch may be said to be the operator at the circuit. He has to deal with forwarded, transmitted, and received messages. Each kind of message has its own peculiar form. The first or forwarded message is written on the A form, which is printed on white paper, and it is the message which is handed in across the counter by the sender himself for transmission by wire. The transmitted message is written on the B form, which is printed on yellow paper, and is the message received at a telegraph office by wire for re-transmission by wire to some other telegraph office. The received message is written on the C form, which is printed on pink paper, and is a message received by wire at a terminal office for delivery by hand from that office. There are other forms used for other kinds of messages, such as service, foreign, press, &c., and in order that the clerk who is about to receive a message may know what particular form to use, every message is indicated by a *prefix*. Thus the letter "S" indicates that a C form must be used; the letter "X" a B form; "S G" a *service* form; "S P" a *press* form, and so on.

Each form has certain columns and entries to be filled up and signalled. The first is the *prefix* alluded to. The second is the "code time," which indicates the time at which the message was handed in by the sender, and which being signalled to the terminal station is copied upon the C form, so that the ultimate receiver of the message knows the exact minute when the message was handed in. This information is not only very useful in itself, but it forms an admirable check by which the public themselves are able to supervise the working of their telegraphs. No message should be delayed more than 30 minutes in its transmission from any part of England to any other part, and if, as a rule, the delay in transmission exceeds this, the public does not discharge its duty as a master if it does not complain to the powers that be.



Time is transmitted by code according to the accompanying diagram.

The twelve letters denote the twelve hours. They also denote the twelve periods of five minutes, of which each hour is composed. The intervening four minutes are denoted by the letters R S W X.

The letters sent *singly* indicate the hours, sent in combination they represent the hours and certain periods of five minutes, sent in connection with the intermediate letters R S W X they represent hours and minutes.

Thus M is 12.	B is 2.
F is 6.	I is 9.
MF is 12-30.	BI is 2-45.
MFS is 12-32.	BIX is 2-49.

After the prefix the code time is the first entry made and signalled, but there are several other entries made—such as the number of words in the address (which are signalled free), the number of words in the message (which are paid for), the number of words in the special instructions as to the mode of delivering the message (which are also free), &c. The total number of words only is signalled, and this is done solely to secure accuracy in transmission, for every clerk immediately he receives a message counts the number of words in it, and if that agrees with the number signalled, he concludes that his message is correctly received; whereas if the numbers disagree, he at once obtains a correction.

Before a message can be sent to any station the attention of that station must be attracted. It must be called and an answer given that the attention of the operator has been secured. In the same way in the presence of a company of men when the attention of one—say Brown—is required "Brown" is shouted and Brown replies by a lusty "here," so every station is supplied with its

"code," or name to distinguish it from every other station, and by this code it is called. There may be several offices on one wire, as for instance Maidstone, Hottingbourne, Lenham, Egerton, Charing, and Ashford. Every current sent operates each instrument alike. Practically all seven stations are in the same space. They cannot see each other, they cannot hear each other, but they are telegraphically together within sight and hearing. So that when Lenham is called the other stations know it but do not answer, in the same way that when Brown is called Smith and Jones do not answer. It would be tedious and uncertain to signal the names of stations in full, hence a "code" or abbreviated name has been given to every office by appropriating the combinations of the letters of the alphabet in groups of two and three. There are 650 combinations of *two* letters and 15,600 of *three* letters, and as there are only 5,400 postal telegraph offices it is evident that no "code" consists of more than three letters. Thus

Rochester	is	indicated by	RR.;
Chatham	,,	,,	CH.;
Sheerness	,,	,,	SH.;
Sittingbourne	,,	,,	SKD.;
Ashford	,,	,,	AD.;
Charing	,,	,,	CEY.;
Egerton	,,	,,	ECN.;
Lenham	,,	,,	LDP.;
Hottingbourne		,,	HIX.;
Maidstone	,,	,,	MA.

When London wants to send a message to Chatham he sends CH. several times in succession until in fact he attracts the attention of Chatham; when the operator at CH. perceives that he is called he simply replies "here CH." then signals the prefix and proceeds with the message.

But there is an inconvenience even in the use of three letters. The combinations frequently and carelessly repeated, sound so much like words, that unless the call be carefully made an inattentive station may conceive that a message is being transmitted between two other stations. The calls also are sometimes like each other; thus C E Y, and K R M, made rapidly are very similar in sound, for the calls are at most universally on all instruments read by sound. Again, as most sub-offices communicate only with their own head offices, complication is unnecessary, hence single call letters for local use have been introduced, viz.:—D, G, K, O, R, S, &c. The sub-office which comes nearest to its head office on the circuit is called D, the next in order G, the next K, and so on, thus, New Brompton—D; Old Brompton—G: Strood—K.

The address, the body of the message itself, and the special instructions transmitted after the message, are all separated from each other by distinct signals, so that the receiving operator may know in what part of the form to write down the words he reads off. The last word of the address is succeeded by D Q; the last word of the text of the message by M M, and until very recently the completion of the message itself was indicated by PQ, but this signal—well known to all old telegraphists—has recently been abolished, because it really had become unnecessary. The ending of the message is either self-evident or it is sufficiently indicated by the prefix of the next message being sent, or by another station being called. These signals are are not written down.

The clerk who receives the message writes it down on the proper form. If it be a message received for delivery to the public an office copy is kept. The C forms are made up in pads and in duplicates, that is—the first copy is the office copy, the next the public form, and so on. The office copy which is kept contains all the entries of prefix, code, time, number of words, &c., which the public do not want to know; the rest of the message which the public does want to know is transcribed on the public copy by carbonic paper, which is slipped into the proper place between the two forms; the message is then delivered. Hence the office copy is in pencil, the public copy in manifold writing.

Upon the A B C and needle instruments every word is acknowledged as it is received. If a word cannot be read repetition is desired, in the former instrument by giving the letter R, in the latter by the letter E. The acknowledgment in the former instrument is Zero, in the latter T. But in the Morse instrument no acknowledgment is given until the message is complete, when, if the total number of words received agrees with the total number signalled and the message appears accurate, the signal R T is sent, followed by the name of the addressee of the message. If the numbers do not agree, or if an error is evident, correction or repetition is obtained.

The operators are supervised, either directly by the postmaster in small offices, or by a superintending or controlling clerk in larger offices. Indeed, in most large offices there is an assistant to the controller, a species of "walking gentleman," whose chief duty it is to carefully inspect the working of every circuit, to keep down delays, to maintain discipline, and to regulate the circulation of the messages. The controlling clerks are subordinate to the postmasters, who are in fact the administrative heads of each office. Post offices are grouped into districts, over which preside surveyors, who are responsible for all matters affecting staff, office accommodation, and discipline in all branches of the Postal Department.

It is scarcely necessary for me to enter further into the details of the mode of charging, entering, abstracting, accounting, delivering, collecting, and checking messages, for they are details more of administration than of organization. In fact the details I have given may appear trivial, but they are given as the lessons of experience, the teachings of failure, the means which scientific thought has given us to secure promptitude and accuracy in the despatch of telegraph messages—methods of which are applicable to all kinds of telegraphy, electrical, mechanical, or visual, and which are equally of use to a military as to a commercial system of telegraphy.

(To be Continued.)

Notes.

The *Faraday* has left for the repair of the Direct United States cable.

The Western Union Telegraph Company are

introducing pneumatic telegraphy on the London system (Clark's), in New York.

The Soirée of the Society of Telegraph Engineers was held on the 21st December, and was a complete success.

The Suez-Aden cable still remains broken down, although by this time the *Chiltern* should have been at work.

On the 16th ultimo, at a meeting of the Eastern Telegraph Company, it was resolved by the shareholders to duplicate their cable between Suez and Aden, and Aden and Bombay, at a cost of £700,000, the capital of the company being increased by the issue of £10 preference shares.

At the meeting held the same day of the Shareholders of the Eastern Extension Telegraph Co., it was resolved to duplicate their system. The resolution agreed to was as follows—

"That the directors be authorised and requested to arrange, on such terms as they may think fit, for the duplication of the company's line between India and the Straits Settlements, for the construction of a line of telegraph between Rangoon and Penang, or between such other points as the directors may determine."

In both cases the directors, who really represent the same interest, had agreed to place the cable work in the hands of the Telegraph Construction and Maintenance Co., who had manufactured and laid the original cables. No better contractors could possibly be found.

It was somewhat strange that at the time of these meetings the two systems beyond Egypt, which so intimately depend upon each other, were broken down. Unquestionably these facts assisted materially to the passing of the resolution.

An interesting question was raised at the meeting relative to the Companies' repairing ships. The *Agnes* left on the 24th of November to repair the Madras-Penang Section which was broken on the 19th; but strange to say, at the date of meeting, she had not been heard of. At the time public intimation was given of these fears she was actually engaged at work on the broken cable to repair the fault, which was ultimately repaired on the 24th December. As regards the *Chiltern*, she was at home when her presence was required at a break about 5,000 miles away. The Chairman announced that the repairing ship was on its way within fourteen days (?) after the mishap.

Now the managing director informed them that keeping a ship at home laid up, saved the company six or seven thousand a year. Now, fourteen days to get the ship ready, nearly a month to arrive at the spot, and other delays, will give quite six weeks. In this question of economy did it ever strike the "economist" the loss of six week's traffic entailed? When the cable was repaired some of the traffic must come back, but not all. Traffic once diverted takes time to return —some never returns.

It is unquestionably a wise proceeding to duplicate this line to India, for the public will benefit by having at least one of the routes always open, because it would be strange were all to be broken at the same time. At present we have the Indo-European, the Eastern Submarine, and the Turkish Asia Minor route to Fao, and thence by the duplicate Persian Gulf route.

As an indication of the energy and enterprise of the South American States on the Atlantic side of that continent, a new Journal has been started, published in Buenos Ayres, and by M. Jules Meeûs, Bruxelles, called "La Plata Industrial y Agricola." Science and telegraphy are duly represented in its pages.

At a board meeting of the Anglo-American Telegraph Company, it was resolved to recommend at the next half-yearly general meeting, to be held at the beginning of February, the payment of a final dividend for the year ending December, 31, 1875, of 1½ per cent. This, with the three interim dividends already paid, will make a total distribution for the year of 5 per cent. A sum of £50,000 out of the year's profits has been placed to a renewal fund, and it is estimated that about £20,000 cash will be carried forward to the next account.

All those who are interested in the literature of Telegraphy should see "Electroplates," by J. Preston, of the Central Telegraph Station, a series of clever sketches drawn on stone, illustrating in Leech's style, the comic side of telegraph life. Some of his portraits are admirable, and his drawings are brimful of wit and humour.

Information arrives from America that Mr. Edison has rivalled Swift's conception of producing sunshine from cucumbers by drawing sparks from steel bar magnets which are not electrical by the manifestation of some unknown force, which he names "etheric force." It is said to be non-polar, to radiate in straight lines like heat, to be capable of transmission to indefinite distances through uninsulated wires, to be unaffected by glass or other nonconductors, and to have other wonderful properties. The last ac-

counts are that *he is trying* to obtain the new force without electric aid, from a simple magnet, and believes that he will yet be able to produce it by means of heat.

THE BAKERIAN LECTURE.

An Account of several new Instruments and Processes for determining the Constants of a Voltaic Circuit.

By CHARLES WHEATSTONE, Esq., F.R.S.,

Professor of Experimental Philosophy in King's College, London, Corresponding Member of the Academy of Sciences at Paris, &c.

Received June 15.—Read June 15, 1843.

(Continued from vol. iii, page 301.)

SECTION 5.—The first instrument is represented in fig. 1. A. *g* is a cylinder of wood, and *h* is a cylinder of brass, both of the same diameter, and having their axes parallel to each other. On the wood cylinder a spiral groove is cut, and at one of its extremities a brass ring is fixed, to which is attached one of the ends of a long wire of very small diameter, which when coiled round the wood cylinder fills the entire groove, and is fixed at its other end to the remote extremity of the brass cylinder. Two springs, *j* and *k*, pressing one against the brass ring on the wood cylinder, and the other against the extremity of the brass cylinder *h*, are connected with two binding screws for the purpose of receiving the wires of the circuit. The moveable handle *m* is for turning the cylinders on their axes. When it is placed on the cylinder *h* and is turned to the right, the wire is uncoiled from the wood cylinder and coiled on the brass cylinder, but when it is applied to the cylinder *g* and is turned to the left, the reverse is effected. The coils on the wood cylinder being insulated and kept separate from each other by the groove, the current passes through the entire length of wire coiled upon that cylinder, but the coils on the brass cylinder not being insulated the current passes immediately from the point of the wire which is in contact with the cylinder to the spring *k*. The effective part of the length of the wire is therefore the variable portion which is on the wood cylinder.

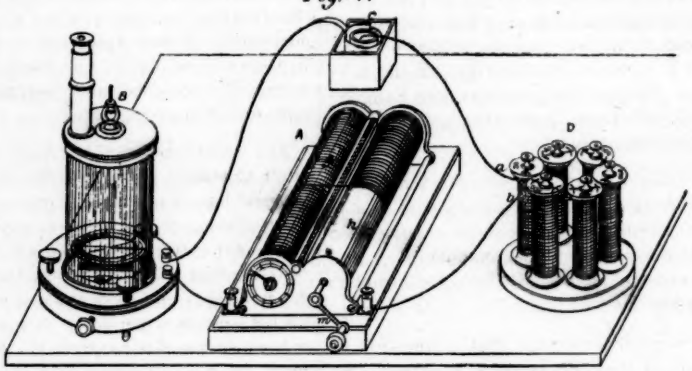
In the instrument I usually employ the cylinders are six inches in length and 1½ inch diameter, the threads of the screw are forty to the inch, and the wire is of brass the 1-100th of an inch in diameter. I employ a very thin wire and a badly conducting metal, in order that I may introduce a greater resistance into the circuit.

A scale is placed to measure the number of coils unwound; and the fractions of a coil are determined by an index which is fixed to the axis of one of the cylinders and points to the divisions of a graduated circle.

As the principal use of this instrument is to adjust or regulate the circuit so that any constant degree of force may be obtained, I have called it a *Rheostat*.

Fig. 1 shows the arrangement of the circuit when prepared for an experiment. B is a delicate galvanometer with an astatic needle furnished with a microscope for reading off the divisions of the circle, which greatly facilitates the observations. C is the rheomotor.

Fig. 1.

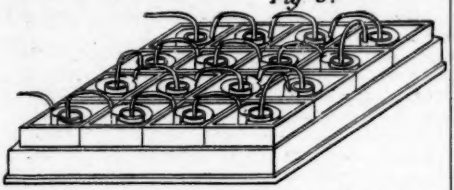


I must here digress for a moment to describe the voltaic element which I have employed in most of my rheometric researches, and which I have found to be very constant in its action, and convenient to manipulate with. It is quite unnecessary to use large elements in such investigations, for when considerable resistances are introduced in the circuits, which is most frequently the case, they produce no perceptibly greater effect than smaller ones, and in all cases the measures may be as accurately determined by employing small elements as large ones.

The voltaic element C consists of a glazed porcelain cell, two inches square and one inch and a half high, in the centre of which is placed a small porous cylinder of earthenware or wood, filled with a liquid amalgam of zinc, the space between the two cells being charged with a solution of sulphate of copper; a slip of thin sheet copper bent round, and having one of its edges cut and turned over so that the wire of the circuit may be attached to it, or that it may dip into the amalgam of another similar cell, is placed in the solution. Fig 3.

represents several such elements combined to form a series. It will be seen that, in principle, this is but a slight modification of Professor Daniell's constant battery, liquid amal-

Fig 3.

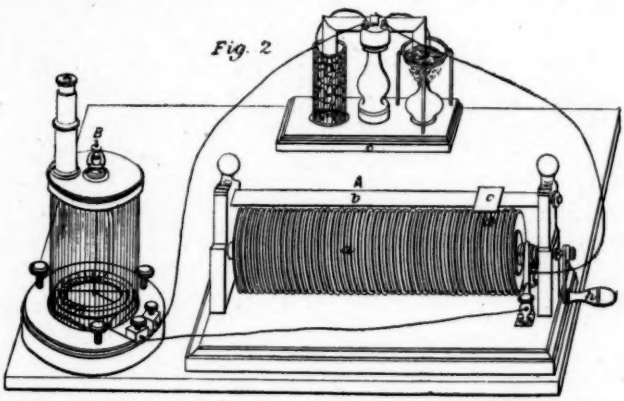


gam of zinc being employed, as in Mr. Kemp's first experiment, instead of amalgamated zinc bars or plates, and the acid solution being dispensed with. This arrangement is, besides being very constant in its action, extremely economical and easy to manipulate. Any negative metal may be substituted for copper provided a solution of a salt of that metal be employed as the interposed liquid.

Section 6.—The rheostat which I employ for circuits in which the resistance is comparatively small is represented at fig. 2. *a* is a cylinder of well-seasoned wood, on the surface of which a spiral groove is cut; a thick copper wire is wound round the cylinder occupying the groove, forming as it were the thread of a screw. Immediately above the cylinder and parallel with its axis is a triangular metal bar *b*, carrying a rider or slide *c*; to this rider a spring *d* is attached, which constantly presses against the spiral wire, yielding to any slight inequality. One end of the spiral wire is attached to a brass ring *e*, against which a spring *f* presses, which is connected by means of a binding screw to one end of the circuit, the other end of the circuit is held by the binding screw which is in metallic connection with the triangular metal bar. On turning the handle *h* the cylinder is caused to move on its axis in either direction, and the rider *c* guided by the wire moves along the bar, advancing or receding according as the cylinder is moved to the right or to the left; the rider coming in contact with a different point of the spiral wire, a different resistance is introduced into the circuit, consisting of that portion of the wire only which is included between the rider and the end of the wire connected with the spring *f*. The cylinder of the instrument I have constructed is 10½ inches in length, and 3¼ inches in diameter; the wire is of copper the 16th of an inch thick, and it makes 108 coils round the cylinder. The dimensions of the instrument, and the thickness, length, and material of the wire, may be varied according to the limits of the variable resistance required to be introduced into the circuit, and the degree of accuracy with which these changes are required to be measured.

Fig. 2 represents the arrangement of a thermo-electric circuit in which this instrument is interposed. C is the thermo-electric element; B the galvanometer, which in this case must not have numerous coils of fine wire as in the preceding arrangement, for this would introduce too great a resistance into the circuit, but must consist of a single thick plate or wire making a single convolution; or, which I think is preferable, the method of diverting a portion of the current from the wire of a delicate galvanometer described in Section 15 may be adopted. Any rheomotor in which the resistance is small may be employed in conjunction with this form of the rheostat, instead of a thermo-electric element, as represented.

Fig. 2



The rheostat, especially under the form last described, may be usefully employed as a regulator of a voltaic current in order to maintain for any required length of time precisely the same degree of force, or to change it in any desired proportion. Interposed in the circuit of an electro-magnetic engine, however the rheomotor may vary in its energy, the same velocity may be constantly restored by turning the cylinder of the regulator to the left or to the right, according as the velocity increases or decreases; or any different velocity, within given limits, may be obtained by adjusting the rheostat accordingly, Since the consumption of materials in a voltaic battery in which there is no local action decreases in the same proportion as the increase of the resistance in the circuit, this method of altering the velocity has an advantage which no other possesses, the effective force is always strictly proportional to the quantity of materials consumed in producing the power, a

oint which, if further improvements should ever

render the electro-magnetic engine an available source of mechanical power, will be of considerable importance.

In volta-typing operations the advantage of using the rheostat is obvious. By varying the rheostat from time to time so as to keep the needle of a galvanometer to the same point, a current of any required degree of energy may be maintained without any notable increase or diminution, for any length of time; and, as the nature of the deposit, when the solution from which it is made remains the same, varies only with the force of the current and the magnitude of the surface on which the metal is reduced, when once a good effect has been obtained the same circumstances may be reproduced with ease and certainty, and the effects of chance entirely eliminated.

In the operations of voltatyping, electro-gilding, &c., and in the production of Nobili's colours, the advantage of using the rheostat is obvious.

This, however, is not the place to dilate on this subject.

Section 7.—*Standard of Resistance.*—It is of the highest importance to have a correct standard of resistance, and one that can easily be reproduced for the purpose of comparison. A copper wire of a given length and diameter might be employed, but as very small differences of diameter are attended with considerable differencees in the resistances of wires, it is more convenient to assume for the unit of resistance a wire of a given length and weight, which allows small differences to be very accurately determined. I shall in all my experiments, therefore, take for the unit of resistance a copper wire one foot in length, and weighing 100 grains. The diameter, of this wire is the ·071 of an inch, and it is intermediate to the numbers designated in commerce as fifteen and sixteen.

Section 8.—*The Resistance Coils.*—It is frequently required to measure resistances much greater than can be effected by means of the rheostat, though the reduced length of its wire is considerable. I may wish to know, for instance, the resistance of the wire of the electro-magnets of my telegraphic apparatus, which is sometimes many hundred yards in length; or that afforded by an extensive telegraphic line, or the resistance of a certain extent of an imperfectly conducting liquid. In all these cases and a variety of others I employ another instrument, which enables me to interpose in the circuit resistances to any amount, and yet to obtain by the conjoined use of the rheostat, which serves as its fine adjustment, any required degree of accuracy. This instrument is represented fig 1, D; it consists of six coils of fine silk-covered copper wire, about the 1-200th of an inch in diameter; two of these coils are fifty feet in length, the others are respectively 100, 200, 400, and 800 feet in length. The two ends of each coil are attached to short thick wires fixed to the upper faces of the cylinders, which serve to combine all the coils into one continued length; the two wires *a*, *b* form the extremities of the coils by which they are united to the circuit. On the upper face of each cylinder is a double brass spring moveable round a centre, so that its ends may rest at pleasure either on the ends of the thick connecting wires, or may be removed from them and rest only on the wood. In the latter position, the current of the circuit must pass through the coil, but in the former position, the current passes through the spring, and removes the entire resistance of the coil from the circuit. When all the springs rest on the wires, the resistance of the whole series of coils is removed, but by turning the springs so as to introduce different coils into the circuit, any multiple of 50 feet up to 1,600 may be brought into it.

As the measurement of these long lengths of wire cannot be accurately depended upon, it is adadvisable to ascertain the number of units of resistance in each coil, which, with the aid of the rheostat, may be easily effected. I find the resistance of the entire 1,600 feet to be equivalent to 218,880 units of resistance, or feet of the standard of wire. I occasionally employ an auxiliary series of coils combined in the same way as the preceding, consisting of six coils of the same wire, each 500 yards in length. The reduced length of this series is above 233 miles of the standard wire. By combining it with the preceding, I am able to measure resistances equal to 274½ miles.

Section 9.—When a perfectly constant element, a galvanometer and a rheostat are placed in a circuit as in fig. 1, the resistance of any interposed body may be ascertained in the following manner. Observe the point at which the needle stands; then remove the body, the resistance of which is to be measured, from the circuit, and, by means of the rheostat, add a sufficient length of wire to bring the needle again to the same point. The number of standard units corresponding to this added length will be the measure.

It is a point of importance to determine the resistance of the wire of the galvanometer employed in the experiments; to ascertain this by the above method an auxiliary galvanometer would be required, but when a second galvanometer is not at hand, recourse may be had to the following process. Take two rheomotive elements exactly equal both in electro-motive force and resistance; place one of them in the circuit fig. 1, and observe accurately the deviation of the needle; then interpose also the other element and bring the needle again to the same point by means of the rheostat. The equivalent of the wire uncoiled λ, will be the measure of the resistance of the galvanometer wire g plus that of the connecting wires r. Subtracting r from λ, the resistance of g will be determined.

$$\frac{E}{R+r+g} = \frac{2E}{2R+r+g+\lambda} \quad \therefore g = \lambda - r.$$

The resistance of a galvanometer wire or any other interposed resistance may be still more accurately ascertained by means of the instruments described in Section 16.

(To be Continued.)

Notices of Books.

Magnetism and Electricity. By FREDERICK GUTHRIE, Professor of Physic at the Royal School of Mines: William Collins, Sons, and Company, 1876.

WHETHER or not there is an opening for another text-book of a purely theoretical nature upon the

subject of "Magnetism and Electricity" is a question upon which different opinions may be entertained, more especially since it is borne in mind that a twelve month has scarcely elapsed since Mr. Fleeming Jenkins' work was published in Messrs. Longmans' series. Still the demands of rival publishers appear to over-ride every other consideration, and we have here in Messrs. Collins' Advanced Science Series, as an extra volume too, "Magnetism and Electricity," by Professor Guthrie.

In the preface, which is written apparently on the "brevity being the soul of wit" principle, we are informed that "this work is intended tor the general student." The wants of the "general" student are now-a-days well looked after, and there is a plethora of manuals and text-books. The publication of a new book, if an indication of a demand, is a healthy sign of the times.

In a text-book we do not look for any new facts in connection with the subject: what we do look for, and have a right to demand from whoever undertakes the work, is that the existing facts shall be made as clear as possible that the diagrams shall be such that they can be followed with ease, and that some show at least of logical treatment should be made in the arrangement of thevarious branches of the subject. Departing from the general custom, Professor Guthrie postpones the subject of magnetism until that of electricity is dealt with. We do not object to this, provided any apparent advantage is to be gained by it. So far, however, from this being the case, the reverse is true, for some knowledge of magnetism on the part of the general student must be assumed before it can be expected that he will successfully grapple with the intricate problems of the electrical relations between currents and magnets, or the measurement of the strength of currents; and on this ground alone, if on no other, we are of opinion that magnetism ought first to be brought under his notice.

The treatment of the work, regarded as a whole, might be improved. At the very commencement we are referred to "Appendix 1" for an explanation of the manner in which shell-lac varnish is to be made; frequent reference is then made throughout the book to "Appendix," although the fact has been apparently overlooked in these foot-notes, that there is an appendix and an appendix; so much so, that after being referred to on the sixth page to "Appendix Y." for the steps to be taken "to make a balanced glass tube," we are, on turning thither, simply advised to "see Appendix B 1 (b)." An appendix of any kind is an objectionable feature in a text-book like this. If it contains matter of any value, then that ought to appear in its proper place in the text; if the matter is superfluous, and not considered worthy of a place in the text, then it should be dismissed from the work altogether, and not tacked on in this fashion to the end of it.

In a scientific text-book no point should be more carefully attended to, although, strange to say, none is more generally neglected than the employment of new terms only after they have been thoroughly defined and their meaning made clear to the reader. This does not form an exception to the general rule, and the student very soon finds himself landed in the midst of a mass of "electro-inducible" matter, "equipotent," "electrogens," and the like. Why "insulators" again have to make way for "isolators," or the term "commutator" to be sacrificed for "rheotrope," we are at a loss to understand, and we had as soon expected to find Mr. Frank Buckland writing of the hippopotam*oi* in the *Z*oological Gardens as to find Professor Guthrie writing of "continuous electrophor*oi*."

The first part of the book deals with frictional or static electricity.

The second part on voltaic electricity, opens with an account of the "Sources of Voltaic Electricity," and the origin of the current is dealt with at some length. We cannot say that Professor Guthrie has been altogether successful in placing clearly before the student the rival contact and chemical theories. Galvanic batteries form the subject of one chapter, and they are treated in what we may now regard as the stereotype fashion. Daniell's battery occupies the position to which it is in every respect entitled. It is first brought under notice, and the arrangement is described at some length. Why Groves' and Bunsen's should next be brought forward, and in company with Daniell's, regarded as *the* batteries in preference to all others, we are at a loss to understand, unless it be that in this case it was deemed undesirable, from the usual method which has hitherto been adopted, of handling the subject. Under the "Other forms of Battery," which, "though not new or yet in general use, are either of historical interest or involve ideas which may hereafter be developed, or which are applicable for special purposes," are included the Leclanché, which is now in general use for telegraphic work in England and France, and the Gravitation which in one or other of its numerous forms are more or less employed in many parts of the globe; the Minotto, is in general use in India, and Messrs. Siemens' and Halske's modification is all but universally adopted in Germany and on the Indo-European lines. Professor Guthrie, in the short allusion to Leclanché's battery, falls into the mistake, by no means uncommon, of speaking of "the elements being zinc and carbon, and the liquid a solution of chloride of ammonium." Mons. Leclanché, writing of his battery, says: "The peroxide of manganese in possessing a certain conductivity of a considerable amount, and analagous to that of the metals, caused me to think of the probability of constructing a constant one-liquid battery by employing a plate of that material as the positive element," and further on, he adds, "In practice, I replaced the plate of peroxide of manganese by pounded peroxide, which I enclosed in a porous pot; the positive electricity of that mass is gathered by means of a plate of carbon." The battery is a one-fluid battery, and is practically a zinc-peroxide of manganese couple, immersed in a solution of the chloride of ammonium.

We turned with interest to the section on the "Amalgamation of the Zinc Plates," for the purpose of learning what opinion so high an authority as Professor Guthrie entertained on this oft-vexed question. We cannot do better, perhaps, than give in full the explanation which is put forward. In Section 163, page 141, we read: "In fig. 133, E represents an easily, and D a difficulty (*sic*) attackable piece of zinc forming one piece. The arrows represent the direction of the current. *A coasting trade.* Such a heterogeneous piece of

zinc when used as an element in a cell fritters away some of its general electro-motive power by establishing local currents. It seems that the chief cause of this inequality of action is due to the difference of hardness rather than metallic impurities, for if the surface of the zinc be moistened with sulphuric or hydrochloric acid and mercury smeared over its surface until the zinc is uniformly amalgamated, such local currents are completely arrested. The metallic impurities cannot certainly be removed in the process of amalgamation. But inequality in hardness, due to irregular cooling, can easily be removed; for as the mercury penetrates, the mass softens and molecular strains are relieved, and uniformity results. This is so complete that amalgamated plates may be left in contact with dilute sulphuric acid for any length of

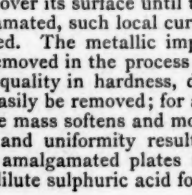


FIG. 133.

time without dissolving, a condition almost indispensible when, as in the telegraph system, batteries are in repeated but intermittent use." We may add that the italics are our own, but we forbear passing any opinion upon the subject.

The diagrams deserve more than a passing word. With their number we do not find fault, for more than 400 separate cuts in a theoretical work, extending over 350 pages, must satisfy even the most exacting in this respect. With the style in which they are executed we do find fault, and not without reason. Take fig. 274, selected at random, as a case in point; it is intended to illustrate the action of a relay, by means of which "the whole strength of the local battery is added to the residue of the distant one, and the electro-magnet is strong enough for printing." Practical telegraphists can gather that a diagram of even more than an ordinary kind is required to render clear this description of the action of a relay. This is taken from a chapter (No. XII) on "The Electric Telegraph and Chronoscope." It is true it does not occupy much space, being confined, including the diagrams, to a little over seven pages, ten lines on the last of which are devoted to the Chronoscope. But why, we are puzzled to know, should the subject have been introduced at all? It could be dealt with only in the most cursory and fragmentary manner, and even supposing for a moment that it had been well done, the subject is out of place in a theoretical work. But when we read that "the great resistance offered by the enormous length of most submarine cables, renders it impossible to employ the current for printing,' and have at the same time before us a well authenticated statement that the Thomson's Recorder works up to 50 words a minute on the Danish cable with Wheatstone's Automatic Transmitter, we see but one more illustration of the old adage that the tools should be given only to those who can handle them, and that to practical men should be left the treatment of practical subjects.

The Day Dreams of a Sleepless Man. By FRANK IVES SCUDAMORE, Esq., C.B. London: Griffith and Farran.

THESE *jeux d'esprit* appeared originally in the columns of the *Standard* and *Scotsman*, and partake very much of the vivacity of a very special correspondent. They sparkle with that wit and facetiousness which is so characteristic of their author. They form a veritable "dictionary of quotations," and indicate the vast reading and tenacious memory of the writer. They contain sketches of Boulogne and its neighbourhood, where Mr. Scudamore sought fresh air and new health, and indicate some of the ways and peculiarities of the inhabitants. The introduction is so pretty that we quote it—

"TO MY CONSTANT READER.

"My dear ——

"I must ever think that I displayed a happy forethought and wise prevision in that I did not commence to scribble until I had first taken steps to provide myself, in you, with at least one constant reader. 'Come what may,' I said to myself, when five and twenty years ago, I dropped my first effusion into the letter box; 'come what may, I have at least secured a public, limited, no doubt, but appreciative, and always in harmony with itself and me.' You, however, have been much more than a constant reader. How often you have extracted, arranged, and indexed notes; how frequently you have hunted up, and verified, or corrected quotations; how often compositors have had reason to bless the days on which you acted as my amanuensis; how frequently, the sleepless wife of a "sleepless man," you have watched and worked by me—these things are known only to me. In all that I have done you have had so large a share that I may say, "*Quod spero, et placeo, si placeo* (which, alas! is an open question) *tuum est.*"

Proceedings of Societies.

THE SOCIETY OF TELEGRAPH ENGINEERS.

On Tuesday, the 21st ult., Mr. LATIMER CLARK, President of the Society of Telegraph Engineers, held the Annual Soirée at Willis's Rooms, St. James's Street, where he received a numerous and distinguished company.

There was a numerous assemblage, both of gentlemen interested in electrical and mechanical science, and those who confine themselves to the less ambitious sphere of practical telegraphy. Among others we noticed Dr. Gladstone, F.R.S., Professor Foster, Dr. C. W. and Mr. Carl Siemens, Mr: Bramwell, C.E., Dr. Warren de la Rue, Mr. Willoughby Smith, Colonel Stotherd, and Majors Webber and Frank Bolton, R.E.; Sir James Anderson, Mr. H. Weaver, and Messrs. Winter, Patey, Graves, Preece, Fischer, &c., of the Postal Telegraphs Departments. There was, as usual, an exceedingly interesting display of electrical and telegraphic apparatus, and of historical objects illustrating the progress and development of telegraphy. Foremost amongst these must be mentioned the

Wheatstone collection, exhibited by Mr. Robert Sabine, C.E., and Mr. B. S. Culley, C.E. This collection is invested with peculiar interest at the present moment, in view of the recent death of the celebrated electrician. The Wheatstone collection begins with the original five-needle telegraph patented by Messrs. Cooke and Wheatstone in 1837, and ends with the capillary mercurial receiver for signalling on submarine cables. A five-needle telegraph was shown, which was in use at one time on the Paddington and Drayton line, and is said to have been the instrument which transmitted the message leading to the apprehension of Tawell, the murderer. Tawell, as will perhaps be remembered, was dressed in the garb of a Quaker in his attempted flight from justice; and as this ancient telegraph, despite its five needles, could not make the letter "Q," the writer is said to have resorted to the expedient of spelling the word "kwaker." The gap in the Wheatstone collection between the earliest and latest efforts of the inventor was filled up by specimens of his well-known A B C telegraph, the automatic telegraph, the Wheatstone Bridge, and the instrument originally devised by him for measuring the velocity of light.

The president, Mr. Latimer Clark, exhibited a most interesting collection of old and extremely rare books on magnetism and electricity, as well as some interesting documents relating to the transfer of the Ronalds library to the Society of Telegraph Engineers, and a bust of the late Sir Francis Ronalds. The original "Thunder House," made by Dr. Priestley with his own hands, contributed by Mr. Conrad W. Cooke; the pneumatic engine-room telegraph of Messrs. Homfray and Co.; the patent apparatus of Messrs. Preece, Gray, and Radcliffe for passenger and guard communication, combining a new method of couplings between carriages, by means of which immediate notice is given in the case of a "break-away." Among submarine cables some interesting specimens were shown by the Secretary, Mr. G. E. Preece, especially one from Norway, which had been operated upon by the *limnoria terebrans*, or cable-borer, and others from Kurrachee, illustrating the preference and dislike of the borer for certain kinds of insulating substances. Two specimens of the Direct United States Cable excited interest. One was a deep-sea specimen, recovered from a depth of 2,240 fathoms, and the other displayed the fracture which occurred off Newfoundland in September last, and which was recovered on the 31st of October. Among what may be termed the scientific playthings of the exhibition, special mention should be made of the electro-magnetic engine, with rotating vacuum tubes, illuminated by a 4-inch spark induction coil, and the 18-inch spark induction coil, displayed along with other interesting objects by Mr. Alfred Apps. The display by Mr. John Faulkner attracted a considerable share of attention, especially that portion of it illustrating the waste and economy of magnetic power; and the Foucault experiment, exhibited by Mr. W. H. Preece, notwithstanding the noise it caused, was regarded with great interest.

The Electromotograph excited much attention. This instrument has been arranged to illustrate a discovery of Mr. Edison of New York. It is an adaptation of the Bain's Printing Instrument. The stylus is tipped with tin and arranged with a spring exerting sufficient force to stay the progress of the chemically prepared paper as it is drawn forward by clockwork. The passage of an electric current decomposes the chemically prepared paper and at once destroys the friction. The stylus is drawn back under the pressure of the spring and is made to strike a bell. On the cessation of the current the friction of the paper again draws forward the stylus.

Some diagrams illustrative of earth currents, by Mr. Alex. Adams, of the Post Office, were interesting, as also Sprague's Universal Galvanometer. Mr. C. E. Spagnoletti had a large display of instruments, explanatory of block signalling, and of lamp and signal repeaters, whilst the new Thermo-Electric Generator of M. Clamond, deservedly attracted numbers. Messrs. Warden and Co. showed their new condensers, and illustrated many experiments, including the method of communicating electrical tones by electricity, invented by Mr. Elisha Gray, of Chicago, which was specially sent over for the soirée.

There were numerous other interesting models and exhibits, but space prevents our further notice. The rooms were excellently decorated, and amongst the extensive display of horticultural beauties, the "India Rubber" plant was especially recognised, as that which has played an important part in telegraphic history. Refreshments were well and continuously provided, and the supper was most inviting, and duly appreciated. The Soirée was unquestionably a great success, and its arrangement, together with that of the "Catalogue" of exhibitors, reflects the greatest credit on those who had the management.

ON THE INFLUENCE OF LIGHT UPON THE CONDUCTIVITY OF CRYSTALLINE SELENIUM.

By WERNER SIEMENS.

The property of crystalline selenium first described by Willoughby Smith, and more closely studied by Sale,* viz. that in the illuminated condition it is a better conductor of electricity than in darkness, I have further investigated, and established the correctness of the facts. The specific conductivity however, of selenium made crystaline by heating to 100° or 150° C. is very slight and extraordinarily variable; the augmentation of the conductivity by illumination is also very inconstant; so that it was impossible to demonstrate a definite dependence of the conductivity upon the illumination. But by protracted heating of amorphous selenium up to the temperature of 210° C., and also by cooling melted selenium to the same temperature of 210° C. (at which, with longer duration of it, the selenium passes into a coarsely granular crystalline state), I succeeded in producing another modification of crystalline selenium, which possesses and permanently retains a considerably greater conductivity, and conducts electricity after the manner of metals, its conducting-power diminishing with rise of temperature. Also the action of the light upon it is far greater, and appears to be

*Proc. Royal Society, vol. xxi. p. 283; Pogg. *Ann.* vol. cl. p. 333

perfectly constant. By fusing into coarsely granular selenium two flat spirals of wire, at a distance of about 1 millim. from each other, between two thin plates of mica, I produced an extraordinarily sensitive photometer. With it obscure heat-rays are *without direct influence* upon the conductivity, which is *diminished* by heating the selenium; while diffused daylight doubles it, and direct sun-light in some circumstances raises it to *more than tenfold*. The augmentation of the conductivity of the coarsely granular selenium by illumination proceeds with extraordinary rapidity. Likewise the lessening of it on shutting off the light appears to commence instantaneously; yet a longer time elapses before the state corresponding to darkness is completely restored. The increment of the conductivity is not proportional to the light-intensity, but a function of it which comes nearer to the ratio of the square root of that intensity.

I defer communicating details on this interesting property until the conclusion of my experiments, merely remarking that I hope to be able to utilize them for the construction of a reliable photometer. —*Monatsbericht der kön. preuss. Akademie der Wissenschaften zu Berlin*, 1875, p. 280.—*Philosophical Magazine.*

THE PERILS OF AUSTRALIAN TELEGRAPHY.

THE *South Australian Register*, of July 14th last, publishes an account of the murder of the station-master at Daly Waters, of the Port Darwin telegraph line, by savages. It says:

"About three weeks ago, Mr. C. H. Johnston, the station-master at Daly Waters, telegraphed for permission to proceed to the Roper River, in order to look after some Government horses and cattle which were known to be straying in that locality. The necessary sanction having been given, he started in company with Messrs. Daer and Rickards and one or two blacks. Nothing more was heard of the party until Tuesday, July 13th, when Messrs. Daer and Rickards returned to Daly Waters with the report that they had been attacked by the natives, and that Mr. Johnston had been murdered. It appears that the attack was made on the 29th of June, Mr. Johnston being speared on the left side of the abdomen. Situated as they were, his companions could do little for him with such a dangerous and probably poisonous wound. The poor fellow lingered till the following day, when, as the telegram informs us, he 'died easily.' Both Daer and Rickards were wounded, the former on the nose, and the latter on the breast, but not seriously. They managed to reach the station, though in a very exhausted condition. With this second painful evidence of the savagery of the aborigines in the interior, it is to be hoped that the utmost care will be taken by the authorities to keep the officers of the various stations as near home as possible. The recovery of a few horses is nothing to the life of a faithful servant; and although in this case the suggestion emanated from the person who lost his life, still, with regard to any such proposed future expeditions, a firm refusal, except under very special circumstances, should be given by the superintendent of telegraphs, and this we are sure, after the tragedy which has just been enacted, he will be careful to do. Mr. Johnston entered the telegraph service in September, 1872; when he was appointed an operator on the overland line. He was stationed at the Katharine, and in May last was transferred to Daly waters."

Correspondence.

To the Editor of the TELEGRAPHIC JOURNAL.

Dec. 13th, 1875.

SIR,—Some time ago I happened to read an "Abstract of a paper on Faults on Telegraph Cables" in your Journal for 1st December, 1874. As I fortunately possess some opportunities and the desire to improve myself, I studied this paper carefully, for I thought it must be good since Mr. Latimer Clark described it as "the most scientific method (of finding faults) with which he was acquainted," and Mr. Preece spoke very highly of it also. Well, I tried to apply it practically first on artificial faults in a tub of salt water, and, secondly, on actual faults, but somehow I have not entirely succeeded, and I am afraid the brief description given in your Journal is not enough. Indeed, if I may make so bold, there would appear to be some errors and omissions.

You would be doing a great service to us poor telegraph clerks, who are anxious to improve our knowledge, if you would kindly publish in your most useful paper a fuller and clearer account of the above method, and if you would please give us your opinion of the value of the different ways of finding faults in cables. As Mr. Fahie's plan is the most accurate and scientific according to Mr. Clark, that method ought to be most widely used, and perhaps you can say from experience whether this is so or not.

Hoping you will pardon the trouble I give you.

A TELEGRAPHER.

[Perhaps a Telegrapher will favour us with his own experiments. Mr. Fahie's plan was to eliminate earth currents, which are scarcely to be found in a tub of salt water.—Ed. *T.J.*]

UNPOLARIZED electrodes are obtained by using amalgamated zinc and a weak solution of zinc sulphate. If there be a free sulphuric acid, it should be neutralized by carbonate of zinc. Common zinc may also thus be used.

Notices to Correspondents.

A STUDENT.—We do not know of any key in use whereby the receiver can stop the sender on a cable or double current circuit. Many have been suggested but they are not employed, probably because they are not wanted.

A SUBSCRIBER IN QUEENSLAND.—Wants a description of the connections required for translation on a *closed* circuit, Morse instruments with relays and local circuits being used. We shall be happy to print the best plan sent us by any of our readers.

W.T.T.—Earth currents are being carefully observed in different quarters of the globe, and the results are being published, but their cause is still a mystery.